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(ii) *The Masai.*

The Masai are a pastoral tribe whose sole occupation is the tending of large herds of cattle, sheep and goats. It has been estimated that they have about 25 head of cattle, and twice as many sheep and goats, per head of the population.

The staple articles of diet are meat, milk, and blood. The blood is drawn from the living animal by puncture of the jugular vein with an arrow. Various roots and barks are used to make infusions which are used either with boiled meat or with milk. The men, while in the "moran," or warrior class, subsist practically entirely on these articles of diet. The rest of the population, in addition to these four items, which form the main part of their food, eat also some bananas, beans, millet, arrowroot, maize, sugar and honey, as these are available. The use of maize, which was introduced only a few years ago, is increasing.

For the greater part of the year there is no scarcity of meat, blood and milk, but in periods of severe drought, when, in spite of the large herds, the milk supply is inadequate, the consumption of these vegetable foods is increased, and even the "moran" may be compelled to supplement their meat and milk diet.

Berries are eaten by the warriors when on safari, *i.e.*, on hunting or fighting expeditions. It appears also to be customary to send the pregnant women into the bush to eat berries. The berries would make an insignificant contribution to the main constituents of the diet, but it is probable that they are of considerable importance as an antiscorbutic addition.

One section of the tribe, the Loitokitok, have adopted a frankly mixed diet. It is of interest that pica among the Masai is confined to this section, who use edible earths from various sources with their vegetable foods.

(*b*) Chemical Composition of Native Foodstuffs, Edible Earths, and Mineral Waters.

The results of the chemical analysis of 153 samples of substances used in the dietary of the two tribes are given in Appendix I. Certain points of interest are discussed below.

(i) *Foodstuffs.*

In the following table a comparison is made between the analyses of the chief Kenya foodstuffs and analyses of similar products grown in other regions, probably in Europe or America, as quoted by Sherman (1926). All the figures are given as grams per 100 grams dry matter.

	Kenya Maize.	*Maize.*
Ca	·005	·011
P	·41	·32
Na	·038	·084
Cl	·05	·058
K	·42	·48

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	Kenya Millet. Red.	*White.*	*Millet.*
Ca	·287	·020	·016
P	·326	·356	·363
Na	·004	·013	·094
Cl	·150	·088	·021
K	·706	·470	·322

	Kenya Potatoes.	*Potatoes.*
Ca	·050	·052
P	·230	·280
Na	·014	·085
Cl	·120	·140
K	2·360	2·030

	Kenya Leaves.	*Cabbage.*	*Spinach.*
Ca	2·66	·57	·83
P	·63	·46	·74
Na	·131	·44	1·93
Cl	·63	·35	·26
K	5·35	4·40	10·13

	Kenya Plantains and Bananas.	*Bananas.*
Ca	·02	·037
P	·14	·119
Na	·045	·240
Cl	·27	·421
K	1·83	1·291

It appears at once that the phosphorus content of the foodstuffs is approximately the same throughout. Potassium tends to be slightly higher in the Kenya foods and is definitely higher in red millet. Chlorine is high in the Kenya leaves and red millet, and approximately the same in the other foods. Calcium is low in maize and bananas, about equal in white millet, but considerably higher in red millet and green leaves. Sodium is low throughout. The high calcium and chlorine content of the Kenya leaves is striking. Indeed, the percentage of calcium in some of the leaves is higher than that previously recorded for any natural foodstuff. Hence, any considerable addition of leaves to a diet of cereals and potatoes or plantains would tend to correct the deficiency of these foods in calcium. In this connection it is interesting to observe that a selective preference for particular leaves appears to exist. From the observations in the field and the replies to the questionnaire, it has been possible to classify the leaves analysed according as they are commonly used by men and women, by women alone, or by women in time of famine only.

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Ca. in grm. per 100 gm. dry matter in leaves used by :—

Leaves.	Men and women.	Leaves.	Women only.	Leaves.	Women in famine.
Mathoroko	3·74	Marenge	1·74	Kalema	2·61
Terere	2·56	Maboco	3·31	Managu	2·43
Togotia	3·46	Ndoma	2·64	Muyuyu	0·85
Hatha	4·52				
Average	3·57		2·58		1·96

Kq
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It has been noted, however, that the tendency throughout the reserve is for men to eat much less of the green leaves than the women do. It is stated that in some districts they eat none. A reason given for this, in a reply to the questionnaire from one of the native chiefs, is that " . . . such food prevented them from being swift of foot if defeated in battle by the Masai."

Estimations of manganese were made in some foodstuffs (Appendix I, Table II). The level in white millet and maize was found to be similar to that found in these foods grown elsewhere, but the manganese content of Kenya green leaves was found to be very much higher than that of edible leaves in this country. The following table shows the nature of the differences found (Richards, 1930) :—

Manganese in mgms. per 100 gms. Dry Matter.

Kenya Samples.		*Home-grown Samples.*	
Red millet	40·19	Oatmeal	6·9
White millet	2·55	Barley	2·01
Green leaves ..	8·93 to 51·31	Cabbage	1·50
Average	30·0	Lettuce	13·30

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[853]

The manganese content of plant ash used as a salt substitute was also found to be very high, the values for two samples being 418 mg. and 352 mg. per 100 gms.

(ii) *Salt Substitutes and Mineral Waters.*

The ashes of water plants (Appendix I, Table IV) largely used as salt substitutes by women, especially during pregnancy and lactation, contain significant amounts of calcium and sodium. The average calcium content of seven samples, procured at native markets or in the villages, is 3·4 per cent., and the average sodium content 7·3 per cent. One of the samples analysed stands out from all the others by reason of its high calcium content, which is 10·60 per cent. as compared with values ranging from 1·0 to 1·5 per cent. for the others. This sample was bought at Wandiga's market, and the ash from this market, and that from neighbouring swamps on the Kagumo River, which is probably identical with it, appears to be more in demand than any of the others mentioned in replies to the questionnaire.

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Of the 15 edible earths analysed (Appendix I, Table V), 13 were definitely richer in sodium than ordinary Kenya soils. The sodium content of these 13 earths ranges from 0·24 to 30·15 per cent. Five of these samples were from the Masai Reserve, and four of them contain high percentages of sodium. The best of these with 30·15 per cent. would form a fair substitute for Magadi soda. In the samples from the Kikuyu Reserve, the highest sodium content is 6·35 per cent.

With regard to the other inorganic constituents, only one of the 13 samples was richer in phosphorus than ordinary Kenya soil. Five of the earths are definitely richer in calcium than soil, ranging from 0·77 to 2·56 per cent. as compared with 0·75 per cent. in soil. Two of these are from an area in the Kikuyu Reserve, and it is interesting to find that they are the most sought after. The source of supply of one of them, viz., Gitirikani earth, which has a calcium content of 1·38 per cent., was at one time in the Masai country. The Kikuyu were then in the habit of making raids and fighting for this salt. They state that their cattle were fatter, bred better, and were more resistant to disease when they had a supply of Gitirikani earth. Similarly in the Masai reserve, the most popular earth is said to be that from Ol Donyorasha, and it has the highest calcium content.

The two edible earths which were not richer in sodium than ordinary soil contained large percentages of iron. These seem particularly popular with pregnant women. On the whole, it is probably true to say that popularity is associated with either a high content in calcium and sodium, or a high iron content.

In addition to plant ash and edible earths, the water from certain springs is held in high esteem, especially by the women, and is used in cooking. Analyses of 15 samples show a fairly high calcium content in some as compared with different waters in Britain (Appendix I, Table VIII), the highest figure being 43·60 parts per 100,000, and the average 9·83.

(iii) *Milk from the Masai Reserve.*

The analyses of 13 samples of milk from different herds of Masai cattle are averaged in the following table and compared with average figures for milk from cows at the Rowett Institute.

	Masai Milk. Per cent.	*Home Milk.* Per cent.
Total solids	13·77	12·89
Fat	5·48	3·9
Sugar	4·92	4·8
Nitrogen	·57	·54
Total ash	·73	·75
Ca	·129	·119
Na	·037	·056
K	·143	·168
P	·095	·100
Cl	·095	·111
Fe	·00008	·00009

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146 It will be observed that total solids and fat content are high in Masai milk. This is probably due chiefly to the low yield, since yield and fat content tend to be inversely related (Tocher, 1925).

With the exception of calcium, the percentage of the inorganic constituents is lower in Masai milk than in home milk. This is especially marked in the case of sodium. Calculated on the caloric basis the difference is still greater, and even calcium is slightly low.

(c) The Composition of the Daily Diet.

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126 An attempt was made by Dr. Foster to collect definite data from which the average amount and composition of the food consumed daily could be estimated.

(i) *The Akikuyu.*

Observations were made on the preparation and eating of food in the native villages. The ingredients and bulk of the foods prepared, and the number of people eating them, were noted In two cases it was possible to have the food weighed for the meals of one day, and samples of the cooked mixture, or of the actual ingredients used, collected for analysis. Other attempts to make accurate observations of this kind failed owing to the belief of the natives that the handling and weighing of the food by Dr. Foster put a "spell"* upon it.

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It will be recognised that little accurate quantitative data with regard to food consumption could be obtained under such conditions. In addition to the difficulty of getting a sufficient number of weighings or measurements, it was impossible to check incidental food consumption. The amounts of maize in the cob, of bananas, or of other foods, eaten while at work in the field or at other odd times, could not be estimated. It is necessary, therefore, to base our calculations on the samples actually weighed, taking those as representative.

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262 The two chief meals of the Kikuyu are:—(1) A sort of thick porridge called "irio" (which means food), of which the main ingredients are maize, legumes and plantains; and (2) gruel "ucuru" made from millet flour and water. These foods are taken with some regularity by both sexes. In addition, maize cobs, yams, sweet potatoes and plantains may also be consumed in considerable quantities, either replacing irio and ucuru when convenient, or

* It is interesting to note that this fear of the natives in the reserves of having a "spell" put upon them, through anything that was done by the investigator, presented great difficulties, not only in connection with the weighing and measuring of food, but also in the weighing and measuring of children. In the reserves, the natives are under the influence of "witch doctors," who evidently resented the practice, in their midst, of what was regarded as a new form of magic.

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It will be seen that the first three estimates are in good agreement with the actual weighings. The fourth, which is an estimate of the upper limit of food intake, probably represents a quantity well above the usual average.

Taking all the available information together, therefore, it is believed that an estimate based on the samples actually weighed and measured forms a sufficiently accurate approximation to the daily food intake.

(ii) *The Masai.*

The assessment of the composition of the diet presents fewer difficulties in the case of the Masai. While a certain amount of differentiation exists between the sexes, it is less marked and of less importance than that between Kikuyu males and females. The following figures show the approximate amounts of the different foods taken :—

Average Diet of Masai Male of Warrior Class.

Meat	1,135 grams.
Milk	2,000 c.c.
Blood	50 c.c.

Average Diet of Women and Males, not Warriors.

Meat	450 grams.
Milk	1,400 c.c.
Maize Meal	250 grams.

(iii) *Comparison of the two tribes.*

On the basis of the above dietaries, the following table has been prepared, comparing the average daily intake of the most important constituents of the diets in the two tribes.

Comparison of probable Average Daily Intake (excluding incidental Food Consumption) of Dietary Constituents by Kikuyu and Masai.

	Kikuyu.			Masai.	
	Males.	Females.		Males.	Females.
		On basis of common diet.	On basis of women's ivio.		
	gms.	gms.	gms.	gms.	gms.
Protein	99	140	82	300	188
Fat	22	20	8	180	90
Carbohyd	390	400	220	100	243
Ca	·28	·46	1·88	2·94	2·03
P	3·0	4·4	2·19	4·38	3·19
Na	·48	·88	1·56	1·80	·94

The above table does not take account of any incidental consumption of maize, sweet potatoes, bananas, or other similar foods, by the Kikuyu. These would increase the caloric value of

the diet without materially affecting the amounts and proportions of the protein, fat and minerals.

From this table it appears that the diet of the Kikuyu male is adequate in protein* (see discussion below p. 20), but very low in fat. It contains more than enough phosphorus but is very low in calcium and possibly low in sodium. If it be assumed that the women alternate common iria with their own dish, then their protein and fat are much as those of the men. Their phosphorus intake is also roughly similar, but their intake of calcium and sodium is much higher than that of the men. Their daily intake of calcium is over 1 gm., and must be considered to be about the optimum intake.

In contrast with this picture, the Masai diet contains a liberal supply of the mineral elements and a large excess of protein and fat, but is low in carbohydrates. It must also be low in cellulose and other indigestible residues.

(d) Physical Condition.

Measurements.

In constructing the tables of physical measurements,[1] the data have been arranged in age-groups, up to and including 30 years of age. Actual ages are, of course, not known by the people themselves and, therefore, only an estimate could be made, but the factor of error will be the same with regard to both Kikuyu and Masai. The figures were arrived at as a result of questioning with reference to outstanding events.

The numbers in the different groups are given in Appendix 2 along with the detailed figures. The results are shown in convenient form in the accompanying graphs, in which they are compared with standard English measurements.

Height.—A comparison of the average heights of Kikuyu and Masai males (Graph 1) of the same age, shows that the Masai grow more rapidly than the Kikuyu and reach a greater mean adult height. At their maximum about the age of 20, there is a difference of almost five inches. At the same age, Masai women (Graph 2) are three inches taller than Kikuyu women. The Masai children appear to grow more rapidly than English children. This may be due to the fact that their chief article of diet is milk, since it has been shown in experiments with Scottish school children that the feeding of additional milk increases the rate of growth (Orr, 1928; Leighton and Clark, 1929). The total number of Masai children measured is, however, too small to make such deductions reliable.

Weight.—Graph 3 compares the rate of increase in weight of Kikuyu children from birth to thirty months of age compared with that of English and of American infants. During the first month the Kikuyu infants are about half a pound lighter than English.

* In considering the relative adequacy of Kikuyu and Masai diets it has to be borne in mind that the biological value of the Kikuyu protein is considerably lower than that of the Masai which is derived from meat and milk.

[1] [See Appendix II, Category 116, pp. 99-80--Analyst]

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child population since those with active yaws are discouraged from attending school. It is known, however, that bone deformities are produced only in the tertiary stage of the disease. Callanan (1928) noted in about 2,000 cases of yaws in children that 32·1 per cent. of male children and 21·6 per cent. of female children had the disease in the tertiary stage. Hence, even assuming that all children have yaws, and that every case of tertiary yaws involves bony deformity, it is obvious that in at least half of the 62·6 per cent. of male children, and 43·7 per cent. of female children with bone deformities, the occurrence of these deformities cannot be explained as due to yaws.

In addition to bone deformities, 40 per cent. of the boys had some obvious dental defect, 48 per cent. were clinically anæmic, and 62 per cent. suffered from spongy gums. There was also a high incidence of enlarged tonsils and cervical adenitis. The general condition was poor.

Kikuyu girls showed a lower incidence of all defects than the boys and were much superior in general condition.

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The Masai village children present a very different picture, bone and dental defects and anæmia being relatively uncommon.

The results of the physical examinations are presented graphically in Graphs 7 to 10. It should be noted that, while there appears to be a correlation between diet and the incidence of bone and dental defects and anæmia, there is none between diet and the incidence of enlarged tonsils and cervical adenitis.

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Table showing percentage Incidence of different Defects in Kikuyu and Masai Children.

	Kikuyu.		Masai.	
	Boys.	Girls.	Boys.	Girls.
Bone deformities	62·6	43·7	11·7	14·6
Dental caries	13·7	13·1	1·6	3·6
All dental defects	40·0	28·8	8·3	7·3
Anæmia	47·8	38·9	11·7	8·5
Enlarged tonsils	56·0	53·3	36·0	32·4
Cervical adenitis	52·0	47·6	40·0	39·8

K M [143]

In the course of the investigation, records of cases attending native hospitals in the Kikuyu and Masai reserves were examined as to the incidence of various conditions. The data for the Kikuyu include figures from the hospitals at Kerugoya, Fort Hall, Nyeri and Githumu. Unfortunately, there is only one hospital in the Masai reserve, that at Narok, the seat of the district commissioner and a trading centre. The patients are therefore not all Masai, about 20 per cent. being Indians or natives of other tribes. We have no information as to the distribution of cases between these and Masai. The following table shows the results expressed as percentages of the number of cases analysed :—

no marked tribal immunity to pulmonary conditions, and that any superior resistance they may show under natural conditions is probably correlated with either superior diet or environment.

It was the general impression of the field worker that disease was less common amongst the women in the Kikuyu reserve than amongst the men. This impression is supported, as far as helminthic infection is concerned, by observations by Vint (1929). In a series of post mortem examinations of 104 cases of men and women, only 19, or 18 per cent., were found free from helminthic infection. Of the 104 cases, 11 were women and 4 of them, or 36 per cent., were free from helminths. Similar evidence is found in clinical records of examinations of fæces at Nairobi Medical Laboratory in which 74 per cent. of men were found to be infected and only 49 per cent. of the women.

Tuberculosis also, as judged by hospital statistics, appears to be less common in women than in men. Wilson (1928) says "There is one noteworthy feature of all our tuberculosis statistics, and that is the overwhelming proportion of male patients," and he also states that pulmonary tuberculosis is rare in native children.

There is, of course, always the difficulty about hospital data that it may be argued that women do not go to hospital as much as the men, but even if this is true, since pulmonary conditions constitute a large proportion of all hospital cases, it seems unlikely that the proportion of women with tuberculosis going to hospital would be lower than that of men.

These indications, taken along with the marked superiority of girls over boys as described from the clinical examination of children, and the admittedly superior general condition of women as compared with men, point to an effect on general condition and health of the difference in diet of the sexes. There can be little doubt that the dietary of the young children, the girls and the women, is better balanced than that of the older boys and men, and this appears to be clearly reflected in differences in physique and health.

III.—LABORATORY AND HOSPITAL WORK.

The laboratory work was carried out by the late Dr. J. M. Henderson in conjunction with Dr. Kelly, Dr. Harvey and other members of the staff of the Medical Research Laboratory in Nairobi, which is under the direction of Dr. W. H. Kauntze. It included analyses of hospital and prison diets and metabolism experiments on native prisoners to determine the effect on weight, composition of the blood, and retention of calcium and phosphorus, of certain additions to these diets.

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(a) A Study of the Adequacy of Hospital and Prison Diets.

The following figures give the prescribed diets and the composition as determined by actual analyses of sample issues.

Native Civil Hospital. Diet "A." Daily ration.		Long Term Prison Diet. Daily ration.		Prison Hospital Diet. Daily ration.	
Beans	6 oz.	Beans	6 oz.	Beans	6 oz.
Beef	6 oz.	Beef*	8 oz.	Beef	8 oz.
Maize (meal) ..	1½ lb.	Maize (whole) ..	1½ lb.	Maize (meal) ..	1½ lb.
Jaggery	1 oz.	Potatoes ..	8 oz.	Potatoes ..	6 oz.
Potatoes and Vegetables ..	6 oz.	Salt	½ oz.	Salt	½ oz.
Salt	½ oz.	Ghee†	1 oz.	Ghee	½ oz.
		Lemons	2 per week.	Lemons	2 per week.

*Given only 3 days per week. †Given only 4 days per week.

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Composition.

	Native Civil Hospital. Average of two samples.	Long Term Prison.	Prison Hospital. Average of two samples.
	gms.	gms.	gms.
Protein	97	116·5	125·3
Carbohydrates ..	487	626	535
Fat	36·8	53·4	48·5
Calories	2,668	3,450	3,079
Fibre	12·3	12	28
Ash	32	20·7	29·3
Ca	·29	·3	·346
P	1·84	2·36	2·65

There are no standards, based on experimental data, for the food requirements of African natives. Breinl and Young (1919–20) reviewing the existing information on dietary requirements in the tropics, conclude that "in general, the requirements in calories, either of white men or coloured natives, does not differ appreciably from European standards." Further, there is no reason to expect that there would be much difference in the relative proportions of the different constituents required. Hence, considering the analyses on the basis of European standards, the caloric value and protein intake appear to be ample. The amount of fat, however, is distinctly below 60 gms., which is regarded by several writers as the desirable amount.

We have little experimental information on the calcium and phosphorus requirements of men. Sherman and his co-workers, from the results of their experiments, consider that the minimum requirement is 0·45 gm. of calcium per man per day. To bring the

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calcium into line with the 100 gm. protein standard, 1 gm. would be required, and this is what Sherman (1920) states to be the desirable amount. The average daily storage for growth has been found by Sherman and Hawley (1922) to be 0·01 gm. per kg. body weight. The amount found by Herbet was 0·01 to 0·016 gm. Hence the requirement for growth in adolescent males would be about 0·5 gm. daily, giving a total requirement of from 1 to 1·5 gms. per day. The calcium content of both hospital and prison diets, amounting on an average to about 0·3 gm. per day, is obviously much below the requirement.

The phosphorus requirement as estimated by Sherman and his co-workers is about 2 gms., corresponding to 1 gm. of calcium. The phosphorus was, therefore, approximately adequate in all diets, and high in the prison diets.

It is impossible to assess in figures the vitamin content of the diets. It was considered, however, that the diets were probably inadequate in respect of vitamins A and D.

The Effect of Additions to the Diet.

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As the examination of the diets had shown that they were probably inadequate in calcium and possibly also in some other inorganic constituents, and that they might also be inadequate in vitamins A and D, it was decided to test the effect of the addition of a mixture of mineral salts and cod liver oil.

Special facilities were given by the Prison authorities for carrying out metabolism experiments on the inmates of Nairobi Gaol. The actual administration of supplements and the collection of material for analysis was under the charge of Sub-Assistant Surgeon Wazir Chand of the Kenya Medical Service.

Experiment 1: *Adults.*

As the diet was low in fat, and as it had been thought that it might be low in iodine, control observations were made with the addition to the diet of an amount of olive oil equal to the amount of cod liver oil given, and with some potassium iodide, so that, in the interpretation of the results, it would be possible to eliminate the possible effects of the added fat or the iodine in the cod liver oil.

The first experiment was made on 42 subjects who were selected from some 200 male natives serving long term sentences. They were selected as belonging to the same tribe or nearly related tribes. They were full grown, free from obvious disease and of average physique. Their occupations were comparable. The men were divided into five groups, there being 14 men in the control group and seven in each of the others. The average weight in each group was approximately the same at the commencement of the experiment.

The fæces of the 42 selected prisoners were examined for protozoal and helminthic infections with a view to having the positive cases

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It is obvious that the subjects were roughly in calcium equilibrium, some showing small negative and others small positive balances. The fact that cod liver oil alone had no effect in promoting an increased calcium retention is probably due to the low calcium intake, 0·3 gm. Ca per day as compared with a probable maintenance requirement of 0·45 gm. per day. This finding is in agreement with those of Schabad and Sorochowitsch (1911) and Schloss (1914), who found that the use of cod liver oil was not always followed by an increased retention of calcium. It is also in agreement with the work of Sherman and Macleod (1925) on rats, in which they found that the addition of cod liver oil to a diet low in calcium had no effect on calcification of the bones.

In the groups receiving the mineral mixture, the balances were usually definitely positive, and the retention was obviously highest in the mineral group receiving cod liver oil. This is in agreement with all recent knowledge of the effect of vitamin D on calcification.

Experiment 2.—*Growing Boys.*

Ka 146 125

The results of the first experiment with full grown men had shown that the addition to the calcium-poor prison diet of either calcium or cod liver oil was followed by a rise in the level of calcium in the blood, and that the addition of calcium or calcium and cod liver oil caused an increased retention of calcium. Since the calcium requirements of adolescents are higher than those of full-grown men, it was decided to carry out balance experiments with youths on this diet to determine (1) whether the calcium intake was sufficient to maintain equilibrium, and (2) the effect on the calcium balance of additions to the diet of (*a*) mineral salts, (*b*) cod liver oil, and (*c*) milk. It was thought that such experiments might give some indication of the calcium requirements of adolescents, a subject on which there is little information in the literature.

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For this experiment, five subjects were chosen as being reasonably comparable in age, physical development, general condition and type of prison employment. The average age of the five was 16 years. One of them was a Masai and the other four were Nandi, whose customary diet is approximately the same as that of the Masai. All were employed on gardening work in Nairobi prison where they were serving long term sentences.

As a preliminary, the Wassermann test was made on the five boys: all were negative. Stools were examined for parasites and blood for evidence of malaria. Similar examinations were made periodically throughout the experiment. Treatment was carried out as required and did not interfere with the experimental work.

The experiment was divided into three periods as follows:—

(1) A preliminary period of three weeks during which the subjects were on the usual long term prison diet.

(2) A period of five weeks during which the prison hospital diet replaced the prison diet.

(3) A supplement period of nine weeks in which the additions as specified below were made.

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Nandi FL13

The basal diets were as already described (p. 20). The additions were as follows:—

Prisoner's No.	*Supplement fed.*
2640	None.
2413	15 c.c. cod liver oil.
1217	Mineral mixture.
2415	Mineral mixture + 15 c.c. cod liver oil.
2534	1 pint cow's milk.

The mineral mixture was identical with that used in the experiment just described. The calcium added to the ration daily in the mineral mixture was 0·68 gm. Ca. From analysis, the calcium content of the milk fed to subject 2534 averaged 0·77 gm. Ca per day. The milk was boiled, as is customary in the Colony.

Results.—(1) *Weight.*

Increases in weight occurred in each case. The largest gains were made by the boys receiving milk and minerals with cod liver oil.

(2) *Blood Calcium.*

The serum calcium was estimated in each of the boys at the beginning of the experiment. The values varied from 10 mg. to 10·6 mg. per 100 c.c. At the end of the supplement period they were practically the same. The average of all the determinations was 10·3 mg., which is within the limits of the normal European range. It is interesting to compare these figures with the previous results on adult prisoners. The latter were all Kikuyu or from tribes with a diet similar to that of the Kikuyu. The average for the 42 cases was 9·2 mg. On the other hand, the boys whose average was 10·3 mg. included one Masai and four Nandi, all with a similar dietary including large quantities of milk. Before admission therefore they would all have had a very high intake of calcium.

(3) *Calcium Balances.*

The calcium balances of each of the five subjects were determined on nine occasions, twice on the prison diet, three times on the prison hospital diet, and four times during the supplement period. The collection period in each case was 96 hours. The following table shows the balances calculated to 24 hour periods.

Average 24 Hour Balances.

Period.	2640 B.	1217 M.M.	2415 M.+C.L.O.	2534 Milk.	2413 C.L.O.
Prison diet .. .. (Ca intake, 0·3 gm.)	+0·0385	−0·0354	−0·2969	−0·1506	+0·0051
Prison hospital diet .. (Ca intake, 0·346 gm.)	−0·0067	−0·1646	−0·2459	−0·0988	−0·2001
Supplement	+0·0434	+0·2509	+0·0962	+0·5058	−0·1364
Ca intake in each case in supplement period.	0·346	1·03	1·03	1·116	0·346

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It will be seen from the table in which the calcium balances are calculated on the analyses already quoted (p. 20), namely, 0·3 gm. for the prison diet and 0·346 for the prison hospital diet, that three of the subjects were on a negative balance on both diets, and two on a positive balance on the former, and a negative balance on the latter diet. We have seen that the calcium in these diets might vary slightly owing to variations in the composition of the beans and potatoes used, but even allowing for the highest figure obtained by analysis, 0·38 gm., the subjects could not have been more than in equilibrium. In growing boys, retention of calcium would have been expected, and indeed, in a later experiment with boys, a small positive balance was found. It is possible that in this experiment, the balance may have been affected by the high calcium intake of the boys on their customary diet before admission to the prison.

Since all the subjects were on the same basal diet, the figures showing the effect of supplement feeding on the calcium balances are comparable. No. 2640 on the basal ration was practically in equilibrium throughout the three periods. The addition of the mineral mixture (No. 1217) changed an apparently negative balance of about 0·1 gm. on an average, to a positive one of 0·25 gm. In No. 2415, the addition of the mineral mixture and cod liver oil changed a negative balance of about 0·27 gm. to a positive one of about 0·1 gm. In No. 2413, the feeding of cod liver oil alone reduced the negative balance of the immediately preceding period, but as compared with the average of the two unsupplemented periods, had no beneficial effect. The greatest difference was seen in the case of No. 2534, the addition of milk changing a negative balance of 0·125 to a positive one of 0·51.

The difference in the calcium balance made by the addition of milk to the diet was therefore 0·63 gm. per day, and the amount of calcium supplied in the milk was 0·77 gm. In the case of the mineral mixture, the amount added was 0·68 gm. and the difference made in the balance was 0·35 gm. This indication of a higher availability of the calcium in milk as compared with that of calcium supplied in other forms is in accordance with the observations of Sherman and Hawley (1922), who found that in children the assimilation of calcium from milk was much higher than from vegetables. The fact that cod liver oil did not materially affect the calcium balances in this experiment would appear to indicate that, in these prison diets, the lack of calcium was of more importance than lack of the factors which affect calcium assimilation. We have already referred to similar findings by other workers.

It is of interest to consider the maintenance requirement in the light of the figures given in the table of calcium balances. The average negative balance of the five subjects throughout the two periods of unsupplemented diet was 0·116 gm. with an average intake of about 0·323 gm. If these figures be accepted as correct, the minimum requirement for equilibrium would appear to be

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0·44 gm. per day, which is in close agreement with Sherman's estimate of 0·45 gm.

Assuming that the maintenance requirement is 0·44 gm. per day, the addition of 0·68 gm. in the mineral mixture would leave a surplus of roughly 0·59 gm. for storage. Of that amount, 0·25 gm. was actually retained, i.e., about 40 per cent. In the case of the supplement of milk, there was a surplus of 0·68 gm., and an actual storage of 0·51 gm. or 75 per cent.

Balance Experiment 3.

The results of the second balance experiment showed that the addition to the calcium-poor basal diet of either milk or a mineral mixture resembling in composition the ash of milk was followed by increased retention of calcium. As cod liver oil without calcium had little effect on the retention, it was assumed that the chief deficiency in the diet was that of calcium itself. To verify this assumption, another experiment was made in which calcium was added to the diet in the form of calcium carbonate and bone flour, the latter supplying inorganic phosphorus as well as calcium. Both are cheap sources of calcium. Milk and green vegetables are expensive, and at certain seasons difficult to obtain, while the elaborate mineral mixture used entailed considerable work in preparation and was also expensive.

For this experiment five Nandi boys, of an average age of 18 years, were chosen as being comparable in physique and general condition. The preliminary treatment of the subjects and the experimental methods were as in the previous experiment.

The basal diet was the prison hospital diet. Analyses showed the calcium in a day's ration to be 0·38 gm. and the phosphorus 2·89 gm. Both were slightly higher than in the last experiment. The calcium carbonate used was a pure sample; the bone flour was a finely ground local product. The supplement feeding was arranged as follows:—

Period.	No.	Diet.
Pre-period—		
Four 2-day collections ..	—	All on prison hospital diet.
First supplement period—		
Eight 2-day collections ..	1901	$CaCO_3$.
	2251	Control.
	2413	Bone flour.
	2428	Bone flour.
	3341	$CaCO_3$.
Post Period—		
Six 2-day collections	—	All on prison hospital diet.
Graded supplement period—		
Five 2-day collections ..	1901	Bone flour.
	2251	$CaCO_3$.
	2428	$CaCO_3$.
	3341	Bone flour.

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Hence the incidence of parasites in ulcer cases is not conspicuously higher than in the general population, and since in 22 per cent. of the ulcer cases the presence of intestinal parasites could not be demonstrated they cannot be regarded as an important etiological factor.

(*e*) *Tribal, sex, and seasonal incidence.*—The most outstanding feature with regard to the tribal incidence of ulcer is that brought out by the survey (p. 34), namely, the high incidence amongst the Kikuyu, and the relatively low incidence amongst the Masai. This is confirmed by the replies to the questionnaire which state that true indolent ulcer is rare amongst the Masai but common amongst the Wakamba, Kavirondo, Kikuyu, Luo and Lumbwa tribes. Ulcer is relatively uncommon also in the Swahilis. We have not sufficient evidence to enable us to say whether racial differences can be correlated with ulcer, but the prevalence of the condition throughout the tropics makes this appear unlikely. With regard to diet, the difference between the Masai and Akikuyu has already been discussed in the first section of this report, and it is known that the Swahili have a mixed dietary. The diets of the other tribes mentioned above, in which ulcer is common, are somewhat similar to that of the Akikuyu.

As regards sex incidence, of the 140 cases studied in this investigation only 3 were women. This however cannot be taken as any indication of the relative incidence in the two sexes, since a high proportion of the cases in Nairobi Hospital are derived from labour gangs. Of the replies to the questionnaire which dealt with the question of sex incidence, 5 stated that ulcer is more common among men, 2 among women, and 4 that there is no sex difference. Among the subjects weighed and measured by the field worker, there were more ulcers in adult females than in adult males, but among the children examined, ulcers were more common in the boys. In the Kikuyu Reserve at least, the women do most of the hard work and are consequently likely to be more exposed to injury than the men. On the whole, the balance of evidence seems to point to a somewhat higher incidence amongst men than amongst women.

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It is interesting to note that the admissions of ulcer cases to hospital commonly increase just as the long rains break. This is a season when disease amongst cattle is said to be more frequent. Since the growth of vegetation, and consequently the diet of both cattle and natives is affected by the rainfall, the high incidence of ulcer at the end of the dry season suggests the implication of a dietary factor.

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Indirect evidence in the same direction is afforded by Breinl's (1915) survey of disease in British New Guinea. He found that there was a marked regional difference in the incidence of ulcer depending on the use of sago as the staple article of diet, and the consequent frequent slight injuries from the spines on the leaves and

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trunk of the sago palm. Although Breinl gives no details regarding the dietary, we know from the work of Cilento (1926) and Strong (1927) that the food of the natives of New Guinea is chiefly carbohydrate, and that the general condition and health is poor. Edge also considers that dietary deficiencies play an important part in the etiology of ulcer.

Such information as could be collected in the present study of the etiology of ulcer seems to warrant the tentative conclusion that neither malaria nor syphilis can be regarded as causative agents. The influence of intestinal parasitic infestation, if any, is not prominent. Trauma is probably an important exciting cause, superimposed upon a condition of low resistance, which is probably the most important factor, in as far as it decreases the natural healing powers and increases susceptibility to invasion by the characteristic micro-organisms. This condition of low resistance may possibly be correlated with dietary deficiencies.

(iii) *Effect of Dietary Treatment on Rate of Healing.*

The effect of various additions to the diet on the rate of healing was studied in 140 cases. These were divided between two wards to facilitate the treatment. The ordinary hospital diet (p. 20) was used as the basal diet. The additions consisted of tomatoes, lemons, cod liver oil, a mineral mixture similar to that used in the prison metabolism experiments, and milk. These additions were, at one time, given all together, later the tomatoes, lemons, cod liver oil and mineral mixture were given in one ward, and milk in the other.

In addition to the dietetic treatment, the routine hospital treatment, consisting of saline baths, eusol dressings and fomentations, and, where indicated, scrapings, was continued.

The patients were weighed regularly, and daily clinical notes were taken of the general condition of the patients and the rate of healing of the ulcers. This material does not lend itself to statistical treatment. All that can be given is a descriptive account, with the conclusions reached by the observer from the mass of detailed data recorded in the course of the investigation.

In the first period, all the supplements referred to above were added to the hospital diet for one ward. This was followed by an improvement in general condition of the patients, increase in weight, and " according to the general impression " of the observer, more rapid healing of the ulcers. Later, the milk ration was withdrawn from this ward and given to the control ward, after which no detectable difference was noted in the rates of healing in the two wards. The milk appears, therefore, to have been of as much value as all the other supplements together.

The observer emphasises the fact that in no case, either with the supplements all together, or separately, was there any dramatic improvement in the rate of healing. The only conclusion possible

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was that the supplements improved the condition of the patients, and pari passu with this improvement there appeared to be a more rapid healing of the ulcers.

This conclusion is supported by a consideration of the gains in weight of the patients and the number of weeks required for recovery, a comparison of which affords the only quantitative measure of the effect of supplement feeding. The data are shown in the following table :—

Age.	20–22.	Over 25.	Under 16.	23–25.	17–19.
Number in group	6	23	32	11	19
Gain per man per week in oz.	13·3	12·8	10·6	8·8	8·4
Weeks to recover	8·3	10·2	10·5	11·7	12·9

It will be seen that the rate of increase in weight is not correlated with the age of the subjects.

The conclusion cannot, however, be taken as more than an indication, since it cannot be assumed that all cases were at the same stage and of the same degree of severity, and since some were discharged before healing was complete.

The dietary tests, therefore, showed that none of the substances tried had any marked effect on the rate of healing, but that the rate of healing appeared to be correlated with the general condition of the patients.

(iv) *Blood Examinations in Ulcer and Non-ulcer Cases.*

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In order to ascertain whether ulcers could be associated with any constant deviation from the normal in the composition of the blood or in physiological adjustments, the calcium and inorganic phosphorus content of the blood were estimated, the sugar tolerance and blood pressure determined, and blood counts made in a number of ulcer and non-ulcer subjects.

(*a*) *Calcium content.*—Estimations of serum calcium were made on 90 prisoners and farm labourers not suffering from ulcers, and on 57 ulcer cases, with 13 Europeans as controls. The following figures show the ranges and averages :—

Serum Calcium—mg. per 100 *c.c.*

Class of case.	No.	Range.	Average.
Prisoners and farm labourers ..	90	7·3 to 11·0	9·4
Ulcer cases	57	7·0 to 11·2	9·7
Ulcer cases on admission	46	7·0 to 11·2	9·6
Ulcer cases on discharge	11	9·7 to 11·2	10·3
Europeans	13	10·7 to 12·5	11·2

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In the absence of further information, it can only be said that the results of this investigation suggest that susceptibility to ulcer, which appears to be general amongst natives on ill-balanced diets of the type mentioned, is correlated with a high blood inorganic phosphate, occurring with a normal, or slightly subnormal calcium, and that the actual occurrence of ulcer is associated with an exaggeration of this abnormality.

IV.—SUMMARY OF RESULTS.

Preliminary observations and a review of existing information suggested that disease is more prevalent amongst native races than is generally supposed, and indicated that the incidence of certain diseases might be correlated with diet.

A survey of two tribes, the Masai and Akikuyu, showed that the diet of the former consisted to a large extent of milk, meat and raw blood, and that of the latter mainly of cereals, roots and fruits, the bulk of the diet being cereals. The outstanding points of difference in chemical composition of the two diets were that the Masai have a relatively very high intake of protein, fat and calcium, while the Kikuyu have a high intake of carbohydrate and a low one of calcium. Differences were found in the dietary customs between men and women in both tribes, the diets of the females approaching in each case to the mean between the diets of the males.

Physical measurements showed that the full-grown Masai male is on an average, 5 inches taller and 23 lb. heavier than the full-grown male Kikuyu, and his muscular strength, as determined by the dynamometer, is 50 per cent. greater. Marked differences were found in the incidence of disease in the two tribes, bony deformities, dental caries and anæmia, pulmonary conditions and tropical ulcer being much more prevalent amongst the Akikuyu. On the other hand, intestinal stasis and rheumatoid arthritis were more common amongst the Masai.

Analyses showed that routine Hospital and Prison diets are markedly deficient in calcium, the average daily intake being only about 0·3 gm. Ca, as compared with the assessed requirement of about 1 gm.

Examination of the blood of Kikuyu and other natives on a similar dietary showed that the concentration of calcium was lower than the European standard, the average of 90 cases, prisoners and farm labourers (not pathological) being 9·4 mg. per 100 c.c. serum, as compared with 10·0 to 10·5 mg. in Europeans at home, and 11·4 mg. in 13 Europeans in Kenya. The range of variation in blood calcium was wide, from 7·3 mg. to 11·2 mg., the highest figure being below the mean for Europeans in Kenya.

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Additions of calcium salts, cod liver oil and milk made to the routine prison diets were followed by an increased retention of calcium varying from about 0·15 to 0·64 gm., the highest retention being procured in the case of calcium salts and milk. Cod liver oil had no definite effect on the calcium balances. In the adult subjects receiving additional calcium or cod liver oil in the diet, the percentage of calcium in the blood was increased.

A description of tropical ulcer, as it occurs in Kenya, is given. A study of the etiology of this condition showed that its occurrence could not be correlated with the presence of syphilis or malaria, nor was there any definite correlation with intestinal parasitic infestation. Examination of the blood showed that the main difference between ulcer and non-ulcer cases was in the blood inorganic phosphorus, which was abnormally high in ulcer cases, distinctly above the level of non-ulcer cases, which themselves showed a higher level than Europeans at home or in Kenya. Thus the ulcer cases showed a marked exaggeration of a tendency common to all the natives examined. Dietetic treatment of ulcer cases gave no definite result. As the state of nutrition of the patient improved the ulcer tended to heal more quickly, but no outstanding effect could be attributed to any of the supplements tried, *e.g.*, minerals, cod liver oil, milk or tomatoes.

A short feeding experiment was arranged at a Reformatory and carried out under the supervision of the Superintendent, observations being made on the rate of increase in height and weight. A distinctly increased rate of growth was obtained by addition of maize alone, maize and bone meal, or milk, to the routine diet, the rate of increase in height being from 30 to 40 per cent. greater than in the control group on the routine diet. The feeding of bone meal with the maize caused an improvement in rate of increase (2·6 per cent.) amongst the younger boys, but none taking all the boys together. Indeed the height increase on a supplement of maize alone was greater than with added bone meal. Unfortunately, arrangements for feeding experiments with larger groups over longer periods could not be carried through.

At the present stage we should not feel justified in attempting a detailed discussion of the results obtained or in attempting to draw definite conclusions therefrom. There is, however, in our view, ground for the following observations:—

The striking difference in physique between the Masai and Akikuyu raises the question to what extent diet can affect the stature and physique of a race. In Scottish experiments with school children it was found that the feeding of milk was followed by increased rate of growth in two successive years with the same children, but there was nothing to show whether this increase represented merely acceleration of growth with a shortening of the growth period, or

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MK 196 whether, if the milk had been continued, there would have been a difference in adult stature. The results of the measurements of the Kikuyu and Masai at first sight suggests the latter alternative. But, MK [199] although there has been a good deal of intermarriage between the two tribes, they were originally of different stock, and we have no information as to whether, or to what extent the differences in stature and physique may be inherited characters. It would be an interesting study to correlate diet and stature in different countries, to ascertain whether any correlation exists between the quality of the diet and mean adult stature.

MK 164 196 K [197] There are differences in the incidence of disease in the two tribes, and one of the tribes, the Akikuyu, show abnormalities in the composition of the blood. The diet of this tribe is very rich in carbohydrate, relatively rich in phosphorus, but deficient in calcium. Experimental data have been brought forward to lend support to the suggestion that deficiencies in the diet, abnormal composition of the blood and reduced susceptibility to certain diseases which have been noted in this tribe, may be correlated. The possibility that diet may influence the susceptibility to certain infectious diseases raises one of the most important problems in nutritional research.

MK 196 With regard to the bearing of the results of the investigation on conditions in Kenya, we are probably justified in concluding that the diet commonly in use amongst the Akikuyu and other tribes of similar customs is badly balanced, being too rich in carbohydrate and deficient in calcium. It is probably deficient also in other substances required as constructive material for growth, and in certain of the vitamins. On the other hand, the Masai, with a diet at the opposite extreme, possibly have too little vegetable food rich in carbohydrate and cellulose. Improvement might be brought about by increasing the use of green vegetables by both tribes, and of milk by the Akikuyu.

ooo The problem is therefore one which concerns not only medical and public health, but also agricultural authorities. A general improvement of agriculture and animal husbandry amongst the Akikuyu will almost certainly be accompanied by an improvement in the health and working capacity of the natives themselves.

This problem is not confined to Kenya. It appears to exist in many different areas in our tropical dependencies. It may be judged from the introductory statements in the early part of this report that the loss of health and efficiency attributable to deficient diet is, therefore, of considerable economic importance.

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APPENDIX I.

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CHEMICAL COMPOSITION OF FOODSTUFFS.

REPORT BY W. GODDEN.

The results are given below of the analysis of 153 samples of materials used in one form or another in the native dietary. These are classified as follows :—

	No. of samples.
Foodstuffs	83
Leaves of trees and shrubs	18
Plant ashes	8
Edible earths	16
Milks	13
Mineral waters	15

In addition, there were 17 samples of pasture and three of soil taken from the land grazed by the cows, from which the milk samples were obtained.

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TABLE I—*Foodstuffs.*

Percentages in Dry Matter.

Foodstuffs.	Nitrogen.	Total ash.	Acid sol. ash.	Calcium.	Sodium.	Potassium.	Phosphorus.	Chlorine.
	%	%	%	%	%	%	%	%
Beans—								
Average of 5 samples ..	4·00	3·88	3·85	0·11	0·042	1·52	0·45	0·02
Range	3·48–4·28	3·44–4·27	3·39–4·20	0·07–0·15	0·031–0·058	1·35–1·65	0·35–0·55	0·01–0·03
Cassava, 1 sample	0·75	5·00	4·91	0·18	0·035	1·93	0·10	0·04
Maize, 1 sample	1·60	1·59	1·58	0·005	0·038	0·42	0·41	0·05
Marrow, 1 sample	1·11	6·73	6·56	0·19	0·015	2·92	0·30	0·27
Matuya fruit, 1 sample ..	1·39	5·79	5·53	0·55	0·131	1·82	0·15	0·28
Millet, red—								
Average of 3 samples ..	1·33	3·58	3·31	0·29	0·004	0·71	0·33	0·15
Range	1·27–1·38	3·41–3·76	3·26–3·35	0·10–0·42	Trace–0·010	0·56–0·83	0·30–0·34	0·12–0·21
Millet, white—								
Average of 6 samples ..	1·98	2·26	1·83	0·02	0·013	0·47	0·36	0·09
Range	1·50–2·98	1·70–3·32	1·64–2·03	0·014–0·031	Trace–0·021	0·39–0·56	0·28–0·41	0·03–0·15
Ndoma, arrowroot—								
Average of 6 samples ..	0·98	6·56	6·52	0·47	0·013	2·68	0·15	0·26
Range	0·49–2·87	3·86–15·33	3·84–15·33	0·19–1·02	0·003–0·030	1·41–6·35	0·09–0·35	0·02–0·51
Ngambura fruit, 1 sample ..	2·27	13·49	13·28	0·65	0·036	4·83	0·50	0·25
Plantains and bananas—								
Average of 17 samples ..	0·74	4·09	4·03	0·02	0·045	1·83	0·14	0·27
Range	0·46–1·08	3·10–5·35	3·06–5·35	0·01–0·04	Trace–0·097	1·20–2·49	0·10–0·22	0·19–0·34
Kippered bananas, 1 sample ..	0·84	5·84	5·09	0·33	0·103	1·86	0·14	0·26
Peas—								
Average of 4 samples ..	3·93	3·83	3·80	0·10	0·042	1·52	0·45	0·02
Range	3·70–4·55	3·20–4·60	3·18–4·52	0·07–0·12	0·019–0·062	1·31–1·89	0·37–0·53	0·01–0·03

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TABLE I—*Foodstuffs*—cont.

Percentages in Dry Matter.

Foodstuffs.	Nitrogen.	Total ash.	Acid sol. ash.	Calcium.	Sodium.	Potassium.	Phosphorus.	Chlorine.
	%	%	%	%	%	%	%	%
Potatoes, European—								
Average of 3 samples ..	1·45	5·55	5·47	0·05	0·014	2·36	0·23	0·12
Range	1·34–1·56	4·43–6·65	4·43–6·45	0·04–0·07	Trace–0·033	2·03–2·68	0·20–0·26	0·09–0·15
Potatoes, sweet—								
Average of 17 samples ..	0·53	3·43	3·34	0·09	0·036	1·41	0·15	0·18
Range	0·34–0·66	2·20–4·45	2·10–4·43	0·02–0·16	Trace–0·101	0·87–2·09	0·10–0·29	0·11–0·38
Sugar cane—								
Average 2 samples	0·25	2·09	1·52	0·10	0·024	0·69	0·06	0·06
Range	0·21–0·28	1·96–2·23	1·27–1·77	0·09–0·11	—	—	0·04–0·08	—
Yams—								
Average of 6 samples ..	1·16	2·52	2·50	0·02	0·016	1·16	0·09	0·02
Range	0·96–1·26	1·49–2·95	1·48–2·92	Trace–0·03	Trace–0·044	0·60–1·53	0·06–0·10	0·01–0·05
Cooked Foods.								
Irio—								
Average of 2 samples ..	2·30	4·09	4·02	0·24	0·150	1·24	0·30	0·28
Range	2·05–2·56	3·58–4·62	3·48–4·59	0·24–0·25	0·030–0·270	1·08–1·40	0·27–0·34	0·10–0·46
Kiruyu, 1 sample	2·29	3·08	2·61	0·06	0·217	0·46	0·32	0·13
Muthio, 1 sample	2·38	2·68	2·25	0·04	0·137	0·40	0·34	0·11
Ucuru, 1 sample..	1·94	2·53	2·25	0·03	0·043	0·52	0·38	0·06
Musuru—								
Average of 2 samples ..	2·63	4·08	4·06	0·13	0·253	0·96	0·30	0·11
Range	2·58–2·68	3·81–4·35	3·77–4·35	0·10–0·15	0·151–0·355	0·83–1·09	0·26–0·35	0·11–0·12
Ngondi, 1 sample	11·56	6·24	6·17	0·31	1·611	0·93	0·29	0·16

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Foodstuffs.

In Table I the results of the analysis of the 83 samples of foodstuffs are summarised. Where a number of samples of the same substance were received, the average figures and the range are given, all percentages being expressed on the dry matter and in terms of the particular element estimated. In many cases different varieties of the same species of plant were submitted, and certain points may be noted with regard to varietal differences.

Thus, amongst the millets, the three samples of the variety, Mugimbi, submitted, were all richer in ash, calcium, potassium and chlorine, and poorer in sodium, phosphorus and nitrogen, than the average for all the millets, whilst for the three samples of the variety, Mwele, the exact reverse was found. A further difference between the two varieties is shown in the manganese content (*vide* Table II), that of Mugimbi being 40·19 mgms. per 100 gms., whereas that of Mwele is only 2·55. Mugimbi is a red millet, Mwele a white millet.

Twelve different varieties are represented in the figures for plantains, but there do not appear to be any outstanding differences in the composition of the different varieties.

The results for European potatoes cover three varieties, and those for sweet potatoes fifteen varieties. In neither case does any one variety stand out from the rest, although there is a fairly wide range of variation between the extremes. The five different varieties of yams also agree amongst themselves fairly closely.

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The cooked Kikuyu foods show a fair amount of difference amongst themselves, owing to differences in the materials used for compounding them. In the case of Irio, for example, the calcium content is high as compared with all the others, probably owing to the fact that Hatha leaves are incorporated to the extent of roughly one part in eight of the mixture. Ucuru, on the other hand, which consists simply of millet flour, is one of the poorest in mineral content. Ngondi, which is a Masai food, differs from all the Kikuyu foods, in that its ingredients, namely, blood, milk and some fat, are all of animal origin. Its outstanding difference from the other cooked foods is its high nitrogen content.

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TABLE II.—*Manganese Content of Foodstuffs, etc.*

(*Expressed as mgms. of Mn in 100 gms. Dry Matter*).

Foodstuff.	*Mn content.*
Bean	2·36
Maize	0·70
Marrow	2·49
Millet (white)	2·55
" (red)	40·19
Pea	2·81
Plantain	1·88
Potatoes (sweet)	2·78
Yam	0·20
Cooked Foods.	
Irio	3·81
Kiruyu	4·54
Muthio	3·84
Mukiro	4·03
Muuru	4·70
Ngondi	0·40

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	Mn content.
Leaves:	
Hatha	41-72
Mabono	28-63
Managa	29-36
Mathoroko	31-31
Muyuyu	30-16
Toroto	8-93
Tugutia	29-66
Plant Ash.	
Maroria	418-0
Marura	352-0
Edible Earths.	
Kimuna	44-26
S. of Manga (Ol Dupai)	15-13

A number of the foodstuffs, selected on the advice of Dr. Foster, were examined for manganese. The results are shown in Table II. Apart from the high figure recorded for the red variety of millet, Mugimbi, and green leaves, the foodstuffs show nothing marked as regards their manganese content. It is of interest to note that, of the cooked foods, Ngundi, of animal origin, is much lower than the others, which are all made from vegetable material.

Kka 14:Orr & Gilks D-4 (no date) 1931 FL12 Maasai FL2 Kikuyu FL10 Kenya FL1 263

TABLE III.—*Green Leaves of Trees and Shrubs.*

Percentages in Dry Matter.

Name of Leaf.	Nitrogen.	Total ash.	Acid sol. ash.	Calcium.	Sodium.	Potassium.	Phosphorus.	Chlorine.
	%	%	%	%	%	%	%	%
Hatha or Hassa, 1 sample	5·11	20·47	19·80	4·52	Trace	3·24	0·46	0·42
Kalema Ka Ndia, 1 sample ..	5·73	14·25	13·48	2·61	0·061	2·29	0·41	0·30
Maboco, 1 sample	4·56	18·45	17·04	3·31	0·086	4·32	0·52	0·55
Managu, 1 sample	5·11	13·71	13·26	2·43	0·148	2·96	0·44	1·95
Marenge—								
Average of 3 samples	5·45	24·34	23·16	1·74	0·343	5·20	1·02	0·51
Range	4·94–6·47	13·53–29·13	13·20–27·58	1·07–1·91	0·057–1·10	4·51–5·50	0·97–1·19	0·47–0·69
Mathoroko—								
Average of 3 samples	4·49	15·81	14·54	3·74	0·056	2·63	0·37	0·30
Range	4·36–4·97	14·59–22·79	13·08–21·97	2·74–4·57	0·035–0·114	2·15–3·02	0·27–0·66	0·20–0·61
Muyuyu, 1 sample	5·01	25·19	25·16	0·85	0·017	10·64	0·34	0·49
Ndoma, 1 sample	5·51	17·52	17·47	2·64	0·095	4·14	0·60	1·24
Terere—								
Average of 4 samples	4·29	23·06	22·59	2·56	0·106	5·73	0·70	0·53
Range	3·81–4·69	16·55–32·77	16·34–31·97	1·67–3·60	Trace–0·185	3·23–7·74	0·48–1·06	0·38–0·88
Togotia—								
Average of 2 samples	5·15	24·62	23·67	3·46	0·166	5·99	0·65	0·64
Range	4·91–5·77	17·30–27·57	16·85–26·42	2·95–3·67	0·117–0·187	3·67–6·96	0·43–0·74	0·53–0·90
Average of 18 samples	4·92	21·11	20·38	2·66	0·131	5·35	0·63	0·63
Range	3·81–6·47	13·53–32·77	13·08–31·97	0·85–4·57	Trace–1·10	2·15–10·64	0·27–1·19	0·20–1·95

14:Orr & Gilks D-4 (no date) 1931 FL12 Masai FL12
Kikuyu FL10
Kenya FL1

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As compared with the other vegetable foodstuffs, the leaves stand out as being high in nitrogen, total and soluble ash, and in calcium, and they are appreciably higher in chlorine. The incorporation of these materials in the mixed cooked foods thus tends to make up for the marked deficiency of calcium, which occurs in all of the simple foodstuffs used by the natives. These calcium figures all appear as high even when compared with the recorded data for such material as alfalfa (1·26 per cent.); red clover (1·07 per cent.) and the highest figure obtained for a highly cultivated British pasture (1·76 per cent.). Three samples of leaves stand out from the remainder, namely, Hatha leaves, and one sample of Mathoroko leaves, with a calcium content of 4·5 per cent. against an average of 2·66 per cent. for the 18 samples, and Muyuyu leaves, which are comparatively low in calcium 0·85 per cent., but exceptionally high in potassium, 10·64 per cent., against an average figure of 5·35 per cent.

TABLE IV.—*Plant Ashes and Extracts.*

	Percentages in Dry Matter.			*Grams per litre.*
	Mararia.	Marura.		Aqueous extract of Itatema root.
	1 sample.	Aver. of six samples.	Range.	
	Per cent.	Per cent.	Per cent.	
Nitrogen ..	0·52	0·16	0·06– 0·45	0·05
Total Ash ..	76·51	86·32	57·77–96·19	2·01
Acid Sol. Ash ..	50·22	39·66	26·86–74·93	2·01
Calcium ..	5·23	3·11	1·07–10·60	0·10
Sodium ..	5·09	7·65	3·43–10·27	0·41
Potassium ..	10·47	3·13	1·61– 5·34	0·58
Phosphorus ..	1·18	0·92	0·51– 1·15	0·02
Chlorine ..	9·62	7·10	3·35–10·89	0·04
Manganese .. (mgrs. per 100 grs.)	410 0	950 0		0·016

Note.—Under Marura, there is one sample, namely that which was obtained at Wandiga's market, which stands out from all the others with a calcium content of 10·60 per cent. The other five are all of the order 1·0–1·5 per cent.

Two types of plant ash were submitted, namely, Mararia, the ash of a swamp reed, and Marura, the ash of a papyrus plant. The former is considerably richer than the latter in calcium, potassium, and chlorine. One of the samples of Marura ash is very much lower in both sodium and chlorine than the other five, but this is probably due to the fact that the particular sample was by no means so completely burnt as the others. Considerable variations may, therefore, be expected in this type of material, due to the conditions of ashing by the native. These materials will make up to some extent for the low calcium and sodium content of the foodstuffs, if added to them during cooking.

Itatema is a short, reedy, swamp plant and the aqueous extract used by the natives, as supplied, was "an infusion of the entire sod, including adherent earth," and contained 2·63 gs. of total solids per litre.

14:Orr & Gilks D-4 (no date) 1931 FL12 Masai FL12
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TABLE V.—*Edible Earths.*

Percentages in Dry Matter.

Area.	Source.	Nitrogen.	Total ash.	Acid sol. ash.	Calcium.	Sodium	Potassium.	Phosphorus.	Chlorine.	Iron.
Kikuyu Reserve:		%	%	%	%	%	%	%	%	%
Nyeri Area ..	Mwanamweru	0·26	90·98	21·08	0·30	0·76	0·29	0·02	0·06	5·64
	Iruri	0·40	87·73	26·96	0·29	0·08	0·32	0·04	0·11	9·30
	Kasuini	0·09	92·48	24·06	0·06	0·35	1·03	0·01	0·19	7·41
	Keru (Fort Hall)	—	89·96	31·58	0·09	0·04	0·16	0·12	—	14·02
	Njengu (Nyeri)	0·06	92·28	29·14	0·37	0·27	0·12	Trace	0·39	12·99
West of Nyeri ..	Lake Naivasha	0·10	92·21	18·77	0·34	4·67	0·21	0·03	0·16	2·80
Nyeri Area ..	Gitirikani	0·13	94·01	23·01	1·38	1·06	0·52	0·04	0·08	4·63
	Gatondu	0·13	92·61	37·32	0·25	0·24	0·15	Trace	0·08	12·67
Fort Hall Area ..	Murao (Kinyagati)	0·08	90·90	29·40	0·48	6·35	0·11	Trace	0·15	6·40
	Kaharati (Munyuangombe) ..	0·51	79·82	39·21	0·77	5·88	0·47	Trace	0·18	11·83
Masai Reserve: ..										
	Kimana	0·10	96·84	83·96	1·04	23·85	0·33	0·05	3·78	2·00
	S. of Manga (Ol Dugai) ..	0·21	90·40	82·95	0·88	30·15	4·52	0·30	0·84	0·48
	Kima	0·02	97·04	6·08	0·50	0·53	0·13	Trace	0·61	2·96
	Ol Donyorasha	0·09	91·61	47·20	2·56	14·76	1·45	0·05	0·76	1·35
	Near R. Siyabei	0·04	92·41	31·80	0·31	9·88	0·66	0·02	0·38	2·58
	Average of 15 samples ..	0·15	91·55	35·50	0·64	6·59	0·70	0·05	0·52	6·47
	Magadi soda	0·03	98·84	98·84	0·07	42·53	0·46	0·01	0·44	0·15

14:Orr & Gilks D-4 (no date) 1931 FL12 Masai FL12
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As might be expected from the nature of the material, the edible earths show considerable variation according to the area from which they are obtained. On the whole, the two elements which occur in the highest amount in these substances are sodium and iron. At the same time, they have a much higher percentage of calcium than phosphorus, the reverse of what the foodstuffs show. The majority of the edible earths are heavily loaded up with silica, the average percentage of ash insoluble in acid being 56 per cent. of the dry matter. Two of the edible earths, namely, that from Kimana, and the one, Ol Dugai, from a special part of the desert, south of the Manga–Laitokitok road, would make fair substitutes for Magadi soda, by virtue of their sodium content.

Ka 146

TABLE VI.—*Milks.*

	Per 100 c.c.			Per 1,000 calories.	
	Kenya.		British.	Kenya.	British.
	Av. of 13 samples.	Range.	Average.		
Total solids ..	13·77	12·53–15·28	12·89		
Nitrogen ..	0·569	0·489–0·668	0·540		
Sugar	4·92	3·69–5·61	4·80		
Fat	5·48	4·45–8·06	3·90		
Ash	0·729	0·657–0·773	0·754	8·28	10·77
Calcium ..	0·129	0·104–0·149	0·119	1·47	1·70
Sodium.. ..	0·037	0·029–0·046	0·056	0·42	0·80
Potassium ..	0·143	0·131–0·158	0·168	1·62	2·40
Phosphorous ..	0·095	0·079–0·107	0·100	1·08	1·42
Chlorine ..	0·095	0·072–0·126	0·111	1·08	1·58
Iron	0·00008	·00006–0·00015	0·00009	0·0009	0·0014

The Kenya milks are, on the average, richer in protein, fat and sugar than British samples, but poorer in ash and all its constituents with the exception of calcium. This poverty is accentuated if the comparison is made on the basis of 1,000 calories as supplied by the milk and then the Kenya milk shows up as deficient in calcium.

Ka [234]

Bearing in mind that the milk yield of the native cows is as a rule very low, (100–150 gallons per annum), on the basis of Dr. Tocher's figures for variation in the composition of milk, it would have been reasonable to expect the Kenya milk to be richer in fat, protein and ash than the British, but poorer in sugar. This is actually true for the fat and protein, but not for the ash and sugar. Similarly certain results, as yet unpublished, obtained at the Rowett Institute, indicate that with a low milk yield, the calcium, potassium and phosphorus percentages might be expected to be low, but the sodium and chlorine high. The results for calcium, sodium and chlorine do not agree with this expectation.

Ka 233 137 146

TABLE VII.—*Pastures Grazed by Milch Cows.*

Percentages in Dry Matter.

	Average of 17 samples. Per cent.	Range. Per cent.
Nitrogen	0·59 ..	0·37– 1·09
Total ash	9·61 ..	6·92–13·51
Acid sol. ash	2·48 ..	1·40– 4·32
Calcium	0·28 ..	0·15– 0·51
Sodium	0·06 ..	0·02– 0·27
Potassium	0·61 ..	0·24– 1·10
Phosphorus	0·11 ..	0·01– 0·24
Chlorine	0·21 ..	0·07– 0·49

14:Orr & Gilks D-4 (no date) 1931 FL12 Masai FL12
Kikuyu FL10

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TABLE VI.

Average Measurements of Chest and Abdomen in Kikuyu and Masai Females

Kikuyu Females.				Masai Females.			
Age.	No.	Chest.	Abdomen.	No.	Chest.	Abdomen.	Age.
Years.		Inches.	Inches.		Inches.	Inches.	Years.
6	40	22·5	21·8	4	21·4	20·7	6
7	36	22·4	21·9	4	22·4	20·1	7
8	41	22·8	22·2	6	22·9	21·9	8
9	43	23·4	22·2	9	23·7	21·8	9
10	51	24·2	22·8	4	25·8	22·9	10
11	61	24·7	23·5	10	25·7	22·9	11
12	49	25·6	24·1	6	26·1	23·4	12
13	48	25·9	24·4	8	25·7	23·3	13
14	31	27·2	25·2	5	26·9	23·8	14
15	46	28·3	25·6	5	28·4	24·5	15
16	49	29·2	26·0	10	30·1	26·3	16
21–25	100	31·0	28·7	70	32·7	29·0	21–25

TABLE VII.

Condition of Kikuyu and Masai Children.

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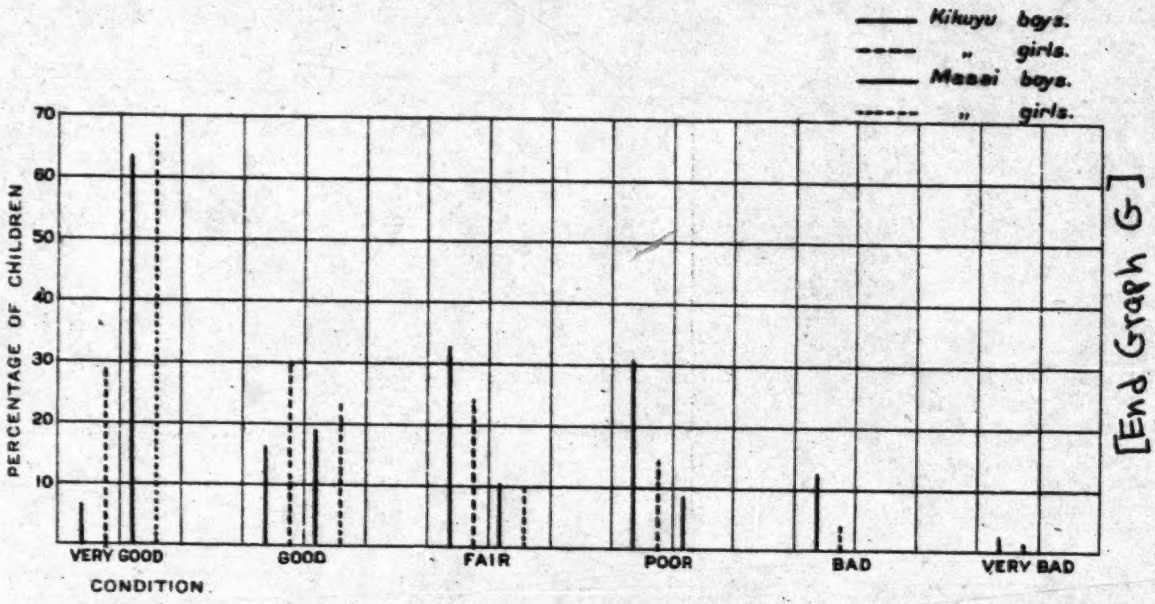
Age Group I.—Up to and including 7 years.

		Very Good.	Good.	Fair.	Poor.	Bad.	Very Bad.
Kikuyu boys—	Per cent.	7·3	16·4	32·4	29·8	12·2	1·9
No. examined ..	.. 262	19	43	85	78	32	5
Kikuyu girls—	Per cent.	28·8	30	23·9	13	3·7	0·6
No. examined ..	.. 347	100	104	83	45	13	2
Masai boys—	Per cent.	63·2	18·4	10·5	7·9	—	—
No. examined ..	.. 38	24	7	4	3	—	—
Masai girls—	Per cent.	66·7	23·1	10·2	—	—	—
No. examined ..	.. 39	26	9	4	—	—	—
Age Group II.—8–11 years.							
Kikuyu boys—	Per cent.	3·5	12·8	36·3	32·2	11·1	4·1
No. examined ..	.. 634	22	81	230	204	71	26
Kikuyu girls—	Per cent.	16·7	26·1	30·9	21·1	4	1·2
No. examined ..	.. 582	97	152	180	123	23	7
Masai boys—	Per cent.	47·4	26·3	15·8	10·5	—	—
No. examined ..	.. 19	9	5	3	2	—	—
Masai girls—	Per cent.	46·6	26·7	16·7	6·7	3·3	—
No. examined ..	.. 30	14	8	5	2	1	—
Age Group III.—12–16 years inclusive.							
Kikuyu boys—	Per cent.	9·1	17·4	35·6	24·4	10·7	2·8
No. examined ..	.. 430	39	75	153	105	46	12
Kikuyu girls—	Per cent.	24·9	33·1	25·3	12·7	2·9	1·2
No. examined ..	.. 245	61	81	62	31	7	3
Masai boys—	Per cent.	100	—	—	—	—	—
No. examined ..	.. 3	3	—	—	—	—	—
Masai girls—	Per cent.	38·5	46·2	7·7	7·7	—	—
No. examined ..	.. 13	5	6	1	1	—	—

14:Orr & Gilks D-4 (no date) 1931 FL12 Masai FL12
Kikuyu FL10

GRAPH 7.

Graph showing condition of Masai and Kikuyu children
Ages up to and including 7 years



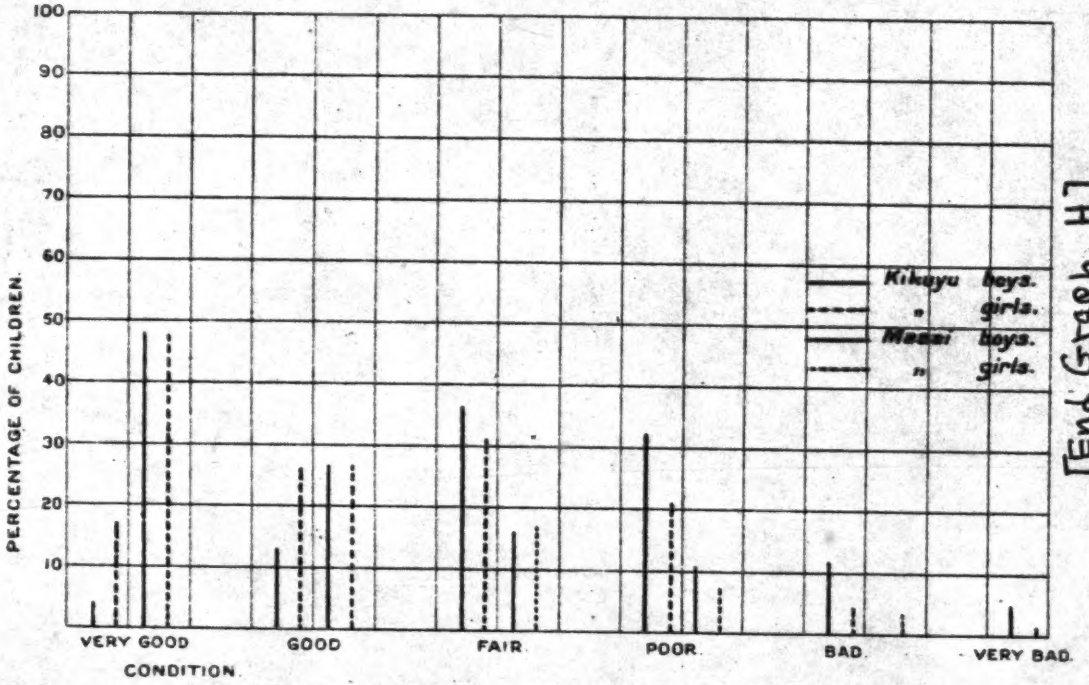
[End Graph G]

KM 146 141

14:Orr & Gilks D-4 (no date) 1931 FL12 Masai FL12
Kikuyu FL10

GRAPH 8.

Graph showing condition of Masai and Kikuyu children
Ages 8 to 11 years inclusive.



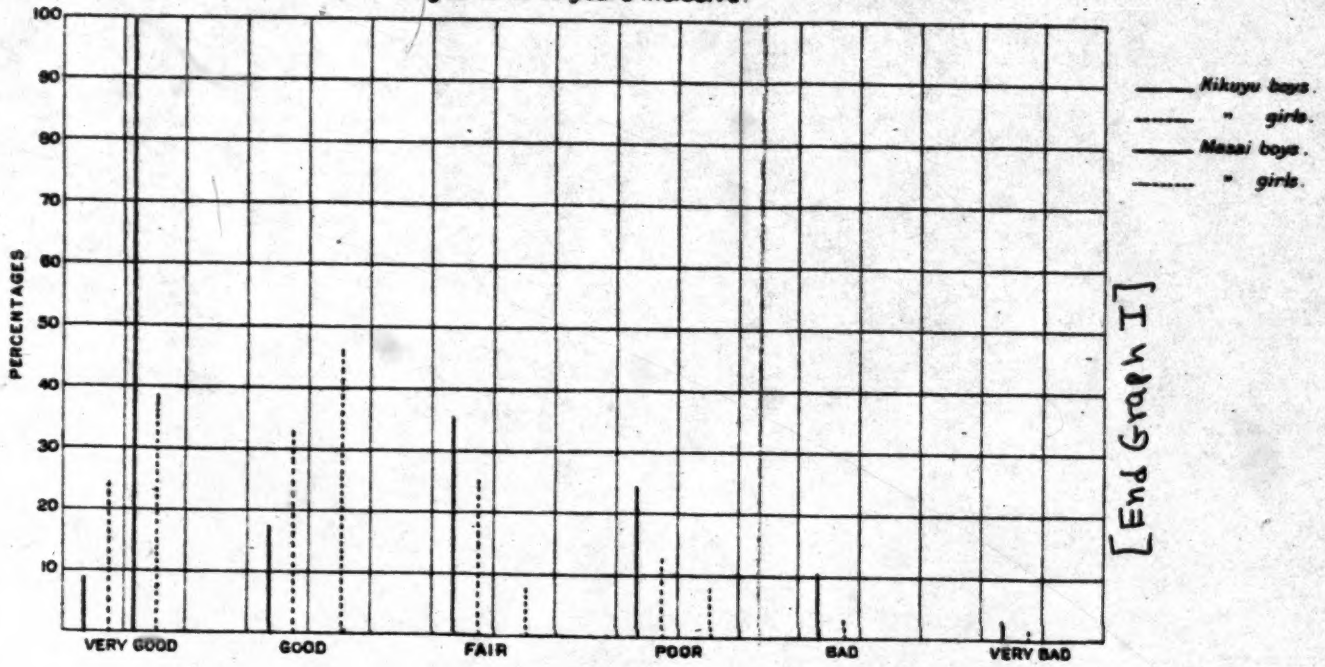
[End Graph H]

KM 146 147

14:Orr & Gilks D-4 (no date) 1931 FL12 Masai FL12
Kikuyu FL10

GRAPH 9.

Graph showing condition of Masai and Kikuyu children ages 12 to 16 years inclusive.



[End Graph I]

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/345 cont./

182 595 shareholder, the rest of the shares are in the hands of his wives, who acquire these shares through the birth of a son. Through this the wives, who have the duty to tend and care for the livestock, are interested in the preservation of the property in the most extensive way. This is the one factor of the polygamy of the Masai promoting prosperity with all its advantages for the political economy. The other lies in the fact that many women give birth to more sons for one man than one woman could. Here, however, male offspring are augmenters of the paternal property. The boy grows up to become a warrior and brings his family the spoils of the numerous raids, through which not only is the herd increased, but, through the supply of new blood, is also improved.

Polygamy among the Masai is therefore a natural institution. Without it large masses of women would be deprived of their natural occupation, a condition that seems impossible for a primitive people. It is, moreover, a source of prosperity, which, among a culture-poor nomadic people, can only make itself felt favorably for their preservation as a people. From it follows, first of all, good nutrition, [146] which makes the body resistant to the effects of illnesses. It corresponds to my observations that among the Masai in general, among [165] adults, fewer cases of death occur as a consequence of illness than [164] is the case among the Negroes living in their vicinity. Also, serious illnesses are more infrequent among them than among the former 182 and are milder in their course. The circumstance that abortion is 847 practiced by the women in only very rare exceptional cases also undoubtedly acts to promote health. One can sufficiently observe the harm that this bad custom has often caused primitive peoples among the various neighbors of the Masai, though indeed there are also exceptions to this. Thus, I met a number of Dschagga women who went through this operation four to six times and allegedly, as well as apparently, without harm.

182 In contrast to the high fertility there is also a rather high child 165 mortality, though infanticide is entirely unknown. It is definitely 854 beneficial for the child that through work the mother is not kept [847] outside the kraal, but can always remain in the vicinity of the child. [853] The long nursing period of about two years is also advantageous.

/345 cont./

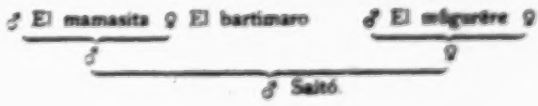
182 Harmful to the child's health, on the other hand, are the poor huts,
165 which are always /346/ filled with dense smoke, and furthermore
854 the lack of cleanliness and the faulty diet. The belief, widespread
[362] among all African primitive peoples, that fat gives strength and
[853] health leads to the stuffing of the baby, despite all its struggles and
• [146] screams, with unbelievable quantities of butter. Soor, as well as
[856] stomach and intestinal affections, and ailments of the respiratory
[164] organs are therefore also the principal illnesses that carry off the babies. If one compares the high mortality among children with the very low one in later life, and if one further considers that, in inspecting the Masai kraals, one finds almost only healthy people full of energy, one cannot resist the thought that the treatment of the children, especially the babies, unconsciously aims at culling out all the weak elements at an early age and preserving for the people only the most vigorous ones that are equal to the demands of life. Seen from this standpoint, that of natural selection, the high child mortality seems less unfortunate. Finally, the late age
182 at which the men enter their first marriage is unfavorable for popu-
582 lation increase. Until about the 28th or 30th year of life the Masai
836 belongs to the warrior standing, and he may marry only after leaving
837 it. This circumstance in turn makes free love, such as exists in the warrior kraals, an understandable social institution. One must judge this arrangement on the soil in which it grows, in order to remain objective. From the same standpoint we shall have to judge more leniently the free love existing among the married, which, despite numerous restrictions, appears to us like a continuous prostitution
[548] of the woman. One can do this all the more since through that professional prostitution is excluded here, and consequently the possibility of infection is greatly reduced; this last circumstance is undoubtedly to be regarded as people-preserving. Actually the Masai
[164] maintain that in former times (before the great livestock epidemics) venereal diseases only very rarely occurred. Immorality is rightly
182 regarded as a people-destroying factor, and history teaches us by
831 many examples how licentious and refined sensuality was one of the grounds that caused the decline of higher peoples. Here among the Masai, however, it is not a matter of this unnatural kind of

/395 cont./

142 Thin. Tonus of the soft parts firm. Skin color: forehead and chest dark-gray--reddish-brown (between 28 and 29); cheek somewhat darker (28); back of hand and scrotum black-reddish-brown (27); nipples somewhat lighter (between 27 and 28). Color of the iris: black-brown with bluish edge. Palpebral fissure set somewhat obliquely, wide-slit. Head hair an inch long, curly. Head, from the crown view, rounded, egg-shaped, with narrow front end, moderately rounded at the occiput. Crown is arched and lies toward the back. Sinciput high, occiput more strongly arched out. Face round to broad-oval. Profile almost orthognathous. Chin vertical. Hair edging of the forehead almost symmetrically curved from ear to ear. Forehead high, steep, full-arched. Nose medium-sized, high, broad. Root of nose moderately deepened toward forehead; bridge straight, tip blunt and directed straight out; nostrils oblique-oval; alae rather flat, their lower edge curved upward. Lips moderately thick. The two middle lower incisors have been pried out. The corresponding upper ones are set somewhat obliquely forward; between them is /396/ a gap 3 mm. wide. The teeth are large, the front ones long and narrow. Both ear-lobes considerably stretched; the upper auricle-edges each pierced once. Foot medium-arched. Second toe juts out. Hand medium slender. Nails large, long. Legs sturdy, somewhat bent inward; slight rachitic curvature on the shanks. [146]

No. 14.

Saitó, ♂, about 27 years old, a native of Sogonoi; ol muli. Lineage: El mamasita.



Medium fat. Tonus of the soft parts firm. Skin color: forehead and cheek dark-gray--reddish-brown (between 28 and 29); chest somewhat darker (28); back of hand and scrotum black-reddish-brown (27); nipples lighter (between 27 and 28); palm of hand

231/272 When they have enough blood, the thong is released and the small wound covered with mud or dung, and the animal runs off apparently none the worse for wear. The blood is drunk warm, or mixed with milk.

• 146 Although they are thin, the Masai appear adequately nourished, and they have great physical endurance. The Ministry of Health doctors told us that Massiland was the only part of East Africa in their experience where the children did not show signs of Kwashiorkor or the other diseases of malnutition that are so common with Africans. Gale (1960) noted that the greatest defect in the diet of the East Africans is lack of animal protein, but this is true of the Masai only in times of extreme drought.

291 [386] Clothing, Jewelry and Utensils The traditional clothing of Masai men and women is an ochre colored cloak of cloth, usually gathered over one shoulder. Some wear skins, usually of sheep. A cow hide is used for a rain coat. Most Masai men wear sandals made from heavy leather or old rubber automobile tires. Very little else is worn by either Masai men or women, except near missions where the women occasionally wear more concealing cloaks.